New Late Cretaceous (Santonian and Campanian) gastropods from California and Baja California, Mexico

Richard L. Squires
Department of Geological Sciences
California State University
Northridge, CA 91330-8266 USA
richard.squires@csun.edu

LouElla R. Saul
Invertebrate Paleontology Section
Natural History Museum of Los Angeles County
900 Exposition Boulevard
Los Angeles, CA 90007 USA
lousaul@earthlink.net

ABSTRACT

Three new genera and six new species of shallow-marine Late Cretaceous gastropods are reported from various formations in California and from one formation in Baja California, Mexico. *Tegula jeanae* new species, of early Campanian age, is the earliest known species of this trochid genus. *Nerita* (subgenus?) *orovillensis* new species is the second known Early Campanian neritid from California. The cerithioid *Bullamirifica* new genus is represented by three species: *Bullamirifica verruca* new species of Coniacian age; *Bullamirifica elegans* new species of early Campanian age; and *Bullamirifica ainiktos* (Dailey and Popenoe, 1966) of middle to late Campanian age. The latter species has the most widespread distribution, with occurrences in southern California and northern Baja California. *Minytropis melilota* new genus and species of Santonian age, and *Paxitropis dicriota* new genus and species of Late Santonian to early Campanian age are high-spired trichotropids. As presently known, *Bullamirifica*, *Minytropis*, and *Paxitropis* were endemic to the study area.

INTRODUCTION

This study is based largely on specimens collected by Eric Göhre of Oroville, California. Over the years, he has amassed a sizeable collection of shallow-marine mollusks from the lower Campanian Pentz Road member of the Chico Formation near Pentz, Butte County, northern California (Figure 1). His collection has yielded several new species of gastropods, and some of these were described by Groves (2004) and Squires and Saul (2004). In part, this present study concerns three additional new species and a new genus of gastropods found in his collection. They are the trochid *Tegula jeanae* new species, the neritid *Nerita* (subgenus?) *orovillensis* new species, and the cerithioid *Bullamirifica elegans* new genus and species.

Inspection of the literature, as well as examination of the collections at the Natural History Museum of Los Angeles County, allowed us to incorporate two additional species into *Bullamirifica*. These are *Bullamirifica verruca* new genus and species from the Coniacian Member IV of the Redding Formation in the Oak Run area, northern California, and *Bullamirifica anikitos* Dailey and Popenoe (1966) new combination from the middle Campanian Pigeon Point Formation southwest of San Francisco, northern California; the middle upper Campanian Punta Baja Formation, Baja California, Mexico; and the upper Campanian Jalama Formation, southern California (Figure 1). "*Cimolithium miyakoense*" (Nagao, 1934) and "*Vicarya* (*Shoshiroia*) *yabei*" Kamada, 1960, reported by Perrilliat-Montoya (1968) from Baja California, Mexico (see Figure 1, formation 6), are judged by us to be synonyms of *Bullamirifica ainiktos*.

Also included in this present study are new trichotropid gastropods found in the collections at the Natural History Museum of Los Angeles County. They are *Minytropis melilota* new genus and species from the Santonian part of the Redding and Chico formations of northern California, and *Paxitropis dicriota*, new genus and species from the of upper Santonian part of the Redding Formation, northern California; the lower Campanian part of the Chico Formation; and the lower Campanian part of the upper Holz Member of the Ladd Formation, southern California (Figure 1).

The geologic age of each new species described in this paper is shown in Figure 2. The entire interval of time that encompasses all these species is Coniacian to late Campanian, or about 19 million years. The new species are locally common, except for *Tegula jeanae*, *Nerita* (subgenus?) *orovillensis*, and *B. verruca*.

The classification system used here generally follows that of Hickman and McLean (1990) for the tegulines, Ponder (1988) for the trichotropids, and Ponder and Warén (1988) for the other taxa.

Study localities are listed in Appendix 1. Abbreviations used in the text are: CAS: California Academy of Sciences.

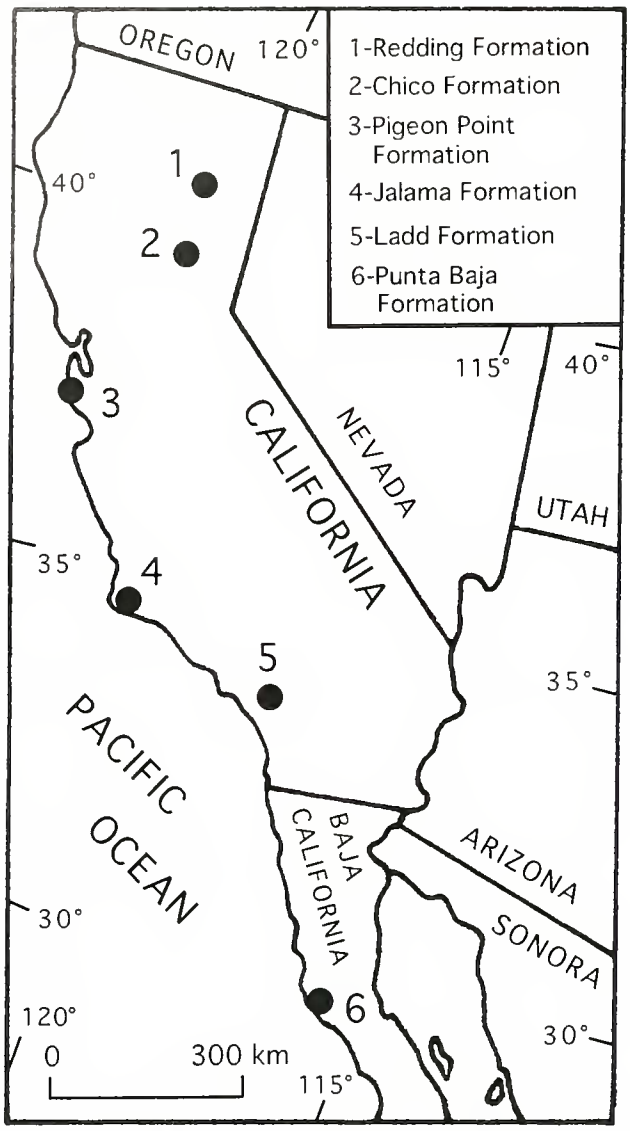


Figure 1. Location of formations bearing the new taxa.

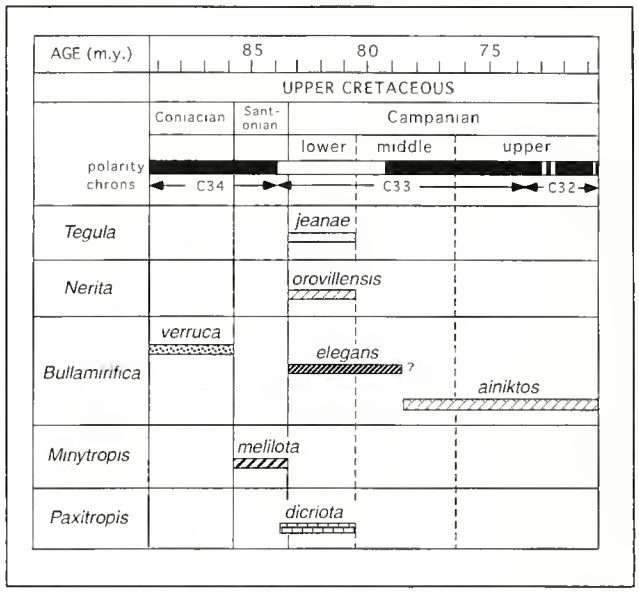


Figure 2. Chronostratigraphic positions of the new taxa. Ages of stage boundaries and magnetostratigraphy from Gradstein et al. (2004, fig. 19.1).

San Francisco; IGM: México Museo del Paleontologia del Instituto de Geologa; LACMIP: Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCLA: University of California, Los Angeles (collections now housed at LACMIP); UCMP: University of California Museum of Paleontology (Berkeley); USGS: United States Geological Survey.

STRATIGRAPHY

Except for the Punta Baja Formation, which is discussed below, the ages and depositional environments of all the formations and members containing the new taxa discussed in this paper can be found in the following papers: Member IV of the Redding Formation, Squires and Saul (2003a); Musty Buck Member of the Chico Formation, Saul and Squires (2003); Pentz Road member (informal) of the Chico Formation, Squires and Saul (1997); Ten Mile Member of the Chico Formation, Squires and Saul (2003b); upper Holz Shale of the Ladd Formation, Squires and Saul (2001); Pigeon Point Formation, Elder and Saul (1993) and Squires and Saul (2003b); and Jalama Formation, Squires and Saul (2003b). The locales of these formations are shown in Figure 1. Stratigraphic information mentioned below concerns additional pertinent biostratigraphic details. The age of the Jalama Formation used here is slightly younger than used in our previous papers because we had to adjust its chronostratigraphic position based on the latest published (Gradstein et al., 2004) absolute-time and global-paleomagnetic data correlations.

Punta Baja Formation

Perrilliat-Montoya (1968) reported specimens of gastropods, herein assigned to *Bullamirifica ainiktos*, from the "Rosario Formation" at Punta Baja, near El Rosario, northern Baja California, Mexico. The 5–140 m thick Punta Baja Formation (Figure 1) overlies fluvial deposits of the La Boeana Roja Formation, and the angular unconformity between these two formations is canyon-shaped (Boehlke and Abbott, 1986). This canyon is filled with conglomerate, sandstone, and siltstone reported by Kilmer (1963) to have been deposited in shallow-marine depths not exceeding 60 meters. Boehlke and Abbott (1986) have a differing viewpoint and reported that the deposits represent turbidites that accumulated in bathyal depths. They reported, furthermore, that shallow-marine mollusks are common, but Kilmer's collection at UCMP does not contain very many specimens. The Punta Baja Formation is unconformably overlain by terrestrial deposits of the La Escarpa Member of the El Gallo

Formation, which, in turn, is overlain by the Rosario Formation.

Based on molluscan fossils collected by F. H. Kilmer, Saul (1983: 21–22, fig. 9) reported the ammonite *Metaplacenticeras* cf. *pacificum* (Smith, 1900) and the gastropod *Turritella chicoensis peseaderoensis* Arnold, 1908, from the siltstone in the Punta Baja Formation. Although these two mollusks were reported by Saul (1983: 65–66) to be of late Campanian age, more recent biostratigraphic studies (Elder and Saul, 1996: fig. 1) depicted both of these taxa as ranging in age from late middle Campanian to earliest late Campanian. Adjustments for the most recently published (Gradstein et al., 2004) absolute-time and global-paleomagnetic data correlations place these ammonite and turritellid zones in the middle late Campanian. Recent examination by the junior author of additional Punta Baja Formation mollusks revealed three specimens of the bivalve *Calva*. The best preserved specimen is from LACMIP loc. 12582 and is *Calva* (*Egelicalva*) *crassa* Saul and Popenoe, 1992, whose geologic range is early late Campanian to early Maastrichtian elsewhere on the Pacific slope of North America (Saul and Popenoe, 1992). The other two *Calva* specimens are worn and broken, from UCMP loc. B-3388. These two specimens are similar to *Calva* (*Calva*) *peninsularis* (Anderson and Hanna, 1935), whose geologic range is latest Campanian to early Maastrichtian elsewhere on the Pacific slope of North America (Saul and Popenoe, 1992).

Boehlke and Abbott (1986: fig. 4) assigned the age of the Punta Baja Formation to the early Campanian based entirely on calcareous nannofossils. They also reported that the benthic foraminifera in this formation correspond to the F2-lower E foraminifera zones of Goudkoff (1945), but they did not rely on the foraminifera for their age call. Almgren (1986: table 2) reported that the F2-lower E foraminifera zones are essentially correlative to the early Campanian to late Campanian. It is important to mention that the Alcalde Shale in the Coalinga area along the west side of the San Joaquin Valley, central California, is correlative to the E zone (Almgren, 1986: table 3). As depicted in Saul (1983: fig. 10), the Alcalde Shale contains *Metaplacenticeras* cf. *M. pacificum*, and Almgren (1986) assigned the Alcalde Shale to the early late Campanian.

In summary, the *Metaplacenticeras*, *Turritella*, *Calva*, and benthic foraminifera data strongly support a middle late Campanian age for the Punta Baja Formation. The calcareous nannofossils, however, support an early Campanian age. It seems probable that the older calcareous nannofossils are reworked, and this would be consistent with the depositional environment of the formation.

SYSTEMATIC PALEONTOLOGY

Superfamily Trochoidea Rafinesque, 1815
Family Trochidae Rafinesque, 1815
Subfamily Tegulinae Kuroda, Habe and Oyama, 1971
Genus *Tegula* Lesson, 1835

Type Species: *Tegula elegans* Lesson, 1835, by monotypy; Recent, west coast of Central America to the Gulf of California, Mexico.

Discussion: Although Wenz (1938), Keen (1960), and Davies (1971) reported the geologic range of *Tegula* to be Miocene to Recent, Bandel and Stinnesbeck (2000) reported a species of *Tegula* of Late Cretaceous (Maastrichtian) age from central Chile. Kiel and Bandel (2001) reported a tentatively identified *Tegula* from upper Campanian strata in northern Spain. The early Campanian new species described below represents the confirmed earliest record we know of for *Tegula*. For the Pacific slope of North America, the previous earliest record of *Tegula* was given by Addicott (1973: 17, pl. 8, figs. 2, 4), who reported it from the Wygal Sandstone Member of the Temblor Formation, southwestern margin of the San Joaquin Valley, Kern County, central California. Squires (2003: table 2.1, fig. 2.1) placed this member in the lower Oligocene Matlockian Stage.

Tegula jeanae new species
(Figures 3–5)

Diagnosis: A *Tegula* with low to moderate spire. Whorls convex, smooth, and bearing one spiral groove on posterior third of last whorl. Anomphalous. Last whorl with raised lip along basal edge, base sunken between this lip and columellar lip, which bears at least one denticle and one much smaller denticle adapically.

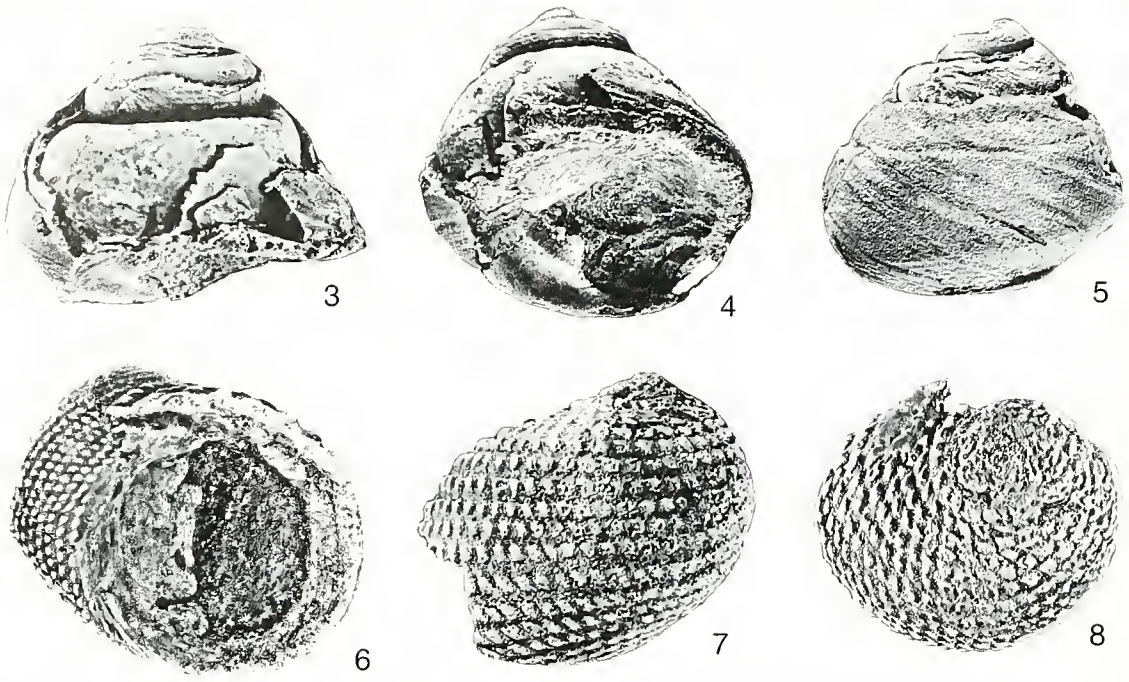
Description: Shell medium (up to 16.6 mm height and 21.7 mm diameter, same specimen). Turbiniform with spire low to moderately elevated. Protoconch unknown. Teleoconch consisting of three whorls. Suture impressed, slightly channeled. Whorls convex, sometimes slightly concave short distance anterior of suture; blunt angulation anterior of medial part of last whorl. Whorls smooth; spiral groove posterior of medial part of last whorl. Aperture oblique, peristome discontinuous. Anomphalous, umbilical area covered by broad callus. Base wide and smooth, peripheral (abaxial) margin coincident with raised lip along edge of last whorl; area depressed between this lip and columella. Outer lip strongly prosocline. Columellar lip with at least one oblique denticle; much weaker second denticle sometimes present immediately posterior of main denticle. Growth lines strongly prosocline, forming wide bands.

Holotype: LACMIP 13322, 18.7 mm in height, 22 mm in diameter.

Paratype: LACMIP 13323.

Type Locality: LACMIP loc. 24337.

Geologic Age: Early Campanian.



Figures 3–8. New tegulid and neritid gastropods. Specimens coated with ammonium chloride. **3–5.** *Tegula jeanae* new species, LACMIP loc. 24337. **3.** Paratype LACMIP 13323, apertural view, height 13.9 mm, diameter 17.9 mm. **4–5.** Holotype 13322, height 18.7 mm, diameter 22 mm. **6–7.** *Nerita* (subgenus?) *orovillensis* new species. **6.** Holotype LACMIP 13324, apertural view, height 11.6 mm, diameter 16.8 mm. **7–8.** Paratype LACMIP 13325, total shell height 10 mm, diameter 13.7 mm. **7.** Abapertural view. **8.** Apical view.

Distribution: Chico Formation, Pentz Road member (informal), near Pentz, Butte County, northern California.

Etymology: Named for Jean Göhre, mother of Eric Göhre, who collected and donated the type material to LACMIP.

Discussion: This new species is known from two specimens, both showing good preservation. The new species is remarkably similar to *Tegula* (*Chlorostoma*) *funebralis* (Adams, 1855), from Pliocene and Pleistocene strata of southern California (Grant and Gale, 1931) and from the Recent of Vancouver Island, British Columbia, to central Baja California, Mexico (McLean, 1978). The new species differs from *T.* (*C.*) *funebralis* by having a smooth shell rather than being ornamented by weak spiral ribs. The similarity between the new species and *T.* (*C.*) *funebralis* is even stronger if the specimens of the latter are worn.

Tegula ovallei (Philippi, 1887: pl. 12, fig. 4; Bandel and Stinnesbeck, 2000: 761, pl. 1, B), the only other positively identified Cretaceous *Tegula* that we know of, is from Maastrichtian strata in central Chile. The new species differs from *T. ovallei* by having a smooth shell rather than being ornamented by granulated spiral ridges.

Kiel and Bandel (2001: 139, pl. 1, fig. 1) reported a tentatively identified *Tegula? simplex* (Quintero and Revilla, 1966: 49, pl. 8, fig. 3) from upper Campanian strata in northern Spain. The new species differs greatly from *T.? simplex* by having a less elevated spire, smooth shell, blunt rather than a sharp angulation anterior of the medial part of the last whorl, broad callus covering the umbilical region, wider aperture, very much stronger denticles on the columella, raised lip along the basal edge of the last whorl, and sunken base between this raised lip and the columellar lip.

Family Neritidae Rafinesque, 1815
Genus *Nerita* Linnaeus, 1758

Type Species: *Nerita peloronta* Linnaeus, 1758, by subsequent designation (Montfort, 1810); Recent, south Florida, West Indies, and Bermuda.

Discussion: *Nerita* sensu lato ranges from Early Cretaceous (Hauterivian), and the earliest record is from the Ono Member of the Budden Canyon Formation, Trinity County, northern California (Saul and Squires, 1997). The new species described below represents the first record of an early Campanian *Nerita* from the study area.

Subgenus?
Nerita (*subgenus?*) *orovillensis* new species
(Figures 6–8)

Diagnosis: A *Nerita* with approximately 18 to 19 beaded spiral ribs. Columellar lip with four or five obscure teeth.

Description: Shell medium small (up to 11.6 mm in height and 16.3 mm in diameter, same specimen), broader than high, globose. Last whorl rapidly expanding. Protoconch unknown. Teleoconch consisting of 2.5 to 2.75 whorls. Uppermost spire very low. Suture obscure. Earliest 1.5 teleoconch whorls apparently smooth, rest of teleoconch covered with approximately 18 narrow spiral ribs bearing small beads; interspaces between ribs approximately as wide as interspaces. Beads on ribs becoming smaller and slightly elongate on base of last whorl, especially in parietal region. Spiral rib adjacent to suture can be slightly stronger than other ribs. Aperture large, nearly circular. Outer lip flared, interior smooth. Columellar lip with five somewhat obscure teeth, most posterior tooth widest and longest. Deck area broad, sloping, and sharply demarcated from base of last whorl. Growth lines prosocline.

Holotype: LACMIP 13324, 11.6 mm in height, 16.8 mm in diameter.

Paratype: LACMIP 13325.

Type Locality: LACMIP loc. 24337.

Geologic Age: Early Campanian.

Distribution: Chico Formation, Pentz Road member (informal), near Pentz, Butte County, northern California.

Etymology: Named for Oroville, California.

Discussion: The new species is based on two specimens. The external surfaces are moderately well preserved, but the columellar lip and especially the deck area are poorly preserved.

The new species is remarkably similar to *Nerita* (*Theliostyla*) *crooki* Clark (1938: 700, pl. 4, figs. 1, 2) from the Markley Formation east of San Francisco, Solano County, northern California. Squires (2003: table 2.1, fig. 2.1) assigned this formation to the middle Eocene ("Tejon Stage"). The new species differs from *N.* (*T.*) *crooki* by having fewer and wider teeth on the columellar lip, fewer ribs on the last whorl with relatively wider interspaces, and ribs near the middle of the last whorl not noticeably broader than adjacent ribs.

The new species is also very similar to *Nerita umzambiensis* Woods (1906: 311, pl. 37, figs. 14–15; Bandel and Kiel, 2003: 51–52, pl. 1, figs. 4–5) from the Santonian/Campanian Umzamba Formation in southeastern South Africa. The new species differs from *N. umzambiensis* by having fewer teeth on the columella lip, ribs on the base of the last whorl, and a deck area sharply demarcated from the base of the last whorl.

The new species somewhat resembles *Nerita* (*Theliostyla*?) *kennedyi* Squires and Saul (2002: 185–187, figs. 31–34) from the upper lower to lower middle Eocene ("Domengine Stage") Santiago Formation, northern San Diego County, southern California. The new species differs from *N.* (*T.*?) *kennedyi* by having beads that are not elongate, wider interspaces between the ribs, and fewer, stronger, and wider teeth on the columellar lip.

The only other early Campanian neritid known from the Pacific slope of North America is *Neritina* (*Dostia*) *cuneata* (Gabb, 1864: 137, pl. 21, fig. 97) from lower Campanian strata at Tuscan Springs on Little Salt Creek, Tehama County, northern California. Gabb's species might also be present in 1) upper Campanian and/or lower Maastrichtian strata in the Pozo area, San Luis Obispo County (Vedder, 1977) and 2) Maastrichtian strata along the western edge of the San Joaquin Valley, California (Woods and Saul, 1986). The new species is vastly different from *Neritina* (*Dostia*) and does not have its patelliform shape nor its distinctive collabral sculpture.

Superfamily Cerithioidea Férussac, 1819
Family Indeterminate

Discussion: The new genus described below is most likely a cerithioid, on the basis of its sigmoidal growth lines, high spire, sculpture, short siphonal canal (slightly twisted), smooth columella, and smooth interior of the outer lip. Some specimens of the new genus have a narrow spire, like that found in cerithioids, but other specimens of the new genus have a buccinid-like shell. The strongly sigmoidal growth lines of the new genus, however, are unlike that found on buccinid shells. It is possible that the new genus belongs to a new cerithioid family.

Genus *Bullamirifica* new genus

Type Species: *Bullamirifica elegans*, new species; Early Campanian, Pentz area, Butte County, northern California.

Description: Shell medium (up to 83 mm height and 37 mm diameter, same specimen), fusiform to turreted. Height to diameter ratio 2 to 2.7. Spire high, comprising 41 to 55% of total shell height. Pleural angle 33 to 42°. Protoconch unknown. Teleoconch whorls six to eight. Spire whorls with shoulder angulate; last whorl with periphery angulate. Ramp short to moderately long, concave to rarely straight-sloped. Suture slightly undulatory, weakly impressed. Collabral sculpture consisting of many narrow ribs, closely to moderately widely spaced; interspaces smooth. Collabral ribs slightly opisthocline to opisthocyrt, usually extending from suture to suture. Collabral ribs present on base or obsolete; if present, swollen and elongate. Spiral sculpture consisting of several spiral ribs with variable width and spacing, especially on last whorl. Spire whorls with strongest spiral rib on whorl shoulder, several weak or moderately strong spiral ribs occasionally near anterior suture, and suture coincident with weak spiral rib either bearing weak nodes or without nodes. Last whorl sculpture with three to four widely spaced, strong spiral ribs on periphery and one or two weaker spiral ribs

or several spiral riblets on base. Intersections of collabral and spiral ribs producing many nodes or strongly projecting tubercles, either rounded (knob-like) to spinose or narrowly elongate. Nodes and knobs most pronounced on whorl shoulder, especially on last whorl. Intersections also strong on anterior portion of last whorl periphery. Aperture short but moderately wide, comma-shaped; small, narrow arch (canal-like) present where outer lip meets most posterior part of aperture. Columellar lip smooth. Siphonal canal short and spout-like or well developed, moderately short, and can be twisted to left. Outer lip thin, markedly sinuous, interior smooth. Growth lines sigmoidal between suture and shoulder; antispiral sinus coincident with tuberculate spiral rib.

Geologic Age: Coniacian to early late Campanian.

Etymology: Combination of the Latin *bulla*, meaning knob, and the Latin *mirifus*, meaning to cause wonder.

Discussion: Three species can be herein assigned to this new genus. Two of these species, *Bullamirifica verruca* and *Bullamirifica elegans*, are based on entirely new material. The third species was originally tentatively assigned by Dailey and Popenoe (1966) to *Pseudoglauconia* Douvillé, 1921. Dailey and Popenoe (1966) stated that this particular species belongs in a new genus, but they withheld their description until better specimens were obtained. Although representatives of the new genus have sigmoidal growth lines (see Wenz, 1940: 764, fig. 2214) similar to that of *Pseudoglauconia*, *Bullamirifica* differs considerably from *Pseudoglauconia* by having a buccinifform rather than a tapered/conical shape, angulate rather than flat-sided whorls, and tubercles on the sides of the whorls instead of only near the suture, and the suture between the penultimate and last whorl is not extremely deep and widely sunken. Unfortunately, the aperture of *Pseudoglauconia* is not known and none of the apertures on the available specimens of *Bullamirifica* is complete. In spite of the absence of knowledge about the aperture of *Pseudoglauconia*, Wenz (1940) believed this gastropod genus to belong in the Cerithiidae.

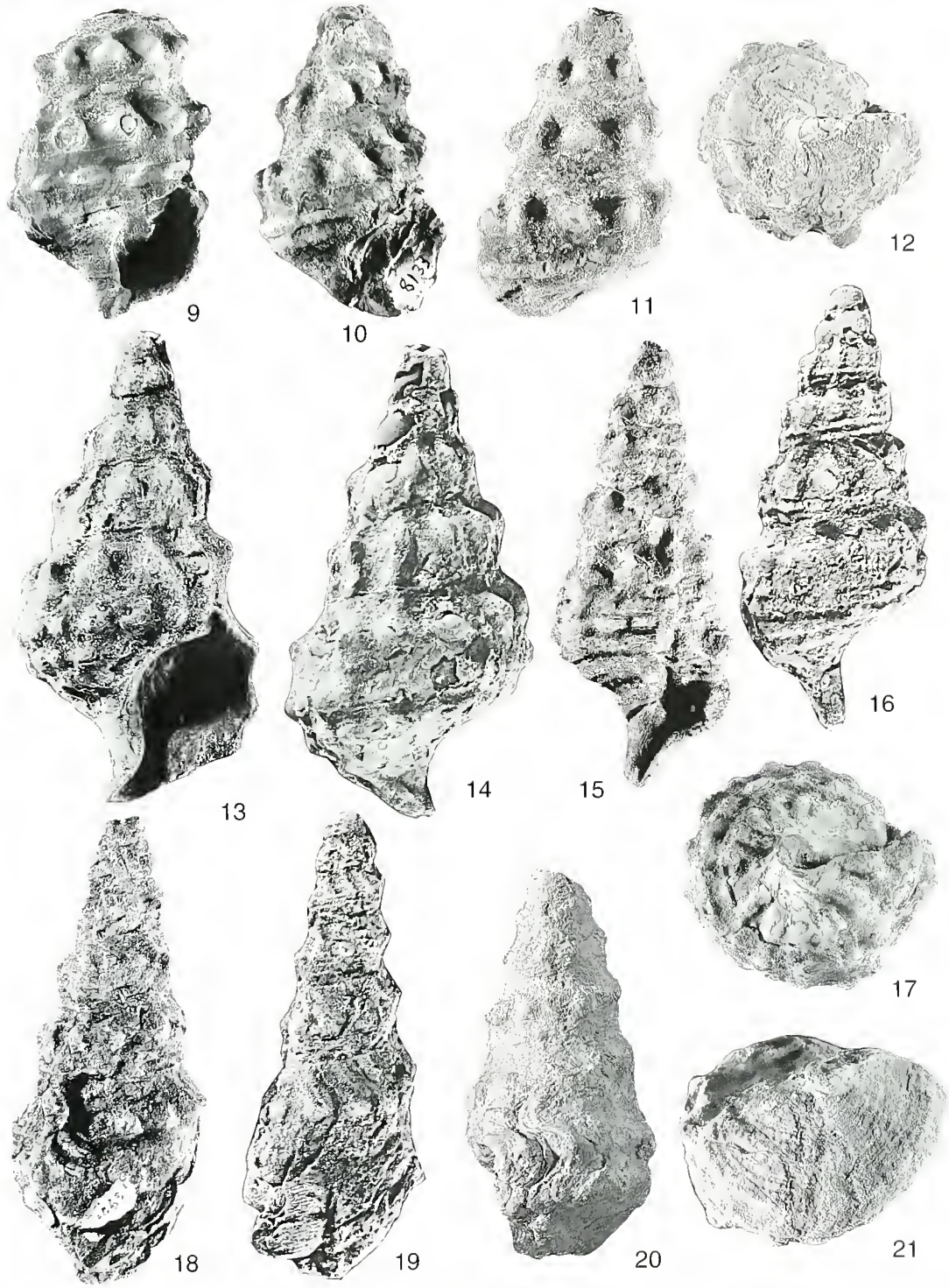
The shape of the growth lines in *Bullamirifica* is similar to that of *Batillaria echinoides clavatulata* (Lamarck, 1804) from the middle Eocene (Lutetian) of the Paris Basin, France. The siphonal canal of this Eocene species is longer than normally found in *Batillaria* Benson, 1842. Ponder and Warén (1988) and Houbrick (1988) placed *Batillaria* in superfamily Cerithioidea, family Batillariidae Thiele, 1929. The similarity in growth-line shape between *Bullamirifica* and *Batillaria* suggests to us that the new genus might be a cerithioid. The high turreted spire of *Batillaria*, however, is quite unlike the lower, more paucispiral spire of *Bullamirifica*.

Bullamirifica has the growth-line shape, shell shape, sculpture, and twisted siphonal canal similar to that of *Pseudorapa* Holzapfel, 1888, a monotypic genus from the Vaals Greensand in the Netherlands and Germany. The age of these strata was determined to be early Campanian by Albers (1976). Wenz (1941: 1083, fig. 3079) illustrated *Pseudorapa*. *Bullamirifica* differs from it by having a less twisted siphonal canal and more variable sculpture, including the possibilities of having spiral ribs and a relatively narrow shell. In addition, *Pseudorapa* has an outer lip that is very crenulate and a spiral band near the base of the last whorl that produces a tooth-like projection on the outer lip.

Bullamirifica verruca new species
(Figures 9–12)

Diagnosis: Small *Bullamirifica* with prominent rounded knobs, nine on shoulder of last whorl. Suture coincident with noded spiral rib. Base of last whorl without elongate collabral ridges. Siphonal canal short and straight.

Description: Small (up to 34 mm estimated height and 16.8 mm diameter, same specimen), fusiform, moderately slender. Height to diameter ratio approximately 2. Spire high, approximately 44% of shell height. Pleural angle approximately 35 to 37°. Protoconch and upper spire unknown. Teleoconch whorls approximately six (estimated). Spire whorls with shoulder angulate, last whorl with periphery angulate. Ramp short, concave. Suture slightly impressed, possibly undulatory. Collabral sculpture consisting of many ribs, widely spaced; interspaces smooth. Collabral ribs slightly opisthocline and extending from suture to suture. Collabral ribs mainly prevalent on ramp. Spiral sculpture consisting of several ribs with variable strength and spacing, especially on last whorl. Intersections of collabral and spiral ribs producing many strongly projecting rounded tuberculate knobs or, less commonly, nodes; knobs and nodes most prominent on shoulder and usually extending posteriorly across ramp and become narrow ridges. Spire whorls with strongest spiral rib on whorl shoulder, very faint spiral riblets present between whorl shoulder and anterior suture. Suture coincident with moderately weak spiral rib bearing small nodes. Penultimate whorl with spiral rib on shoulder bearing nine, moderately closely spaced knobs. Last whorl with three spiral ribs on periphery, strength of ribs progressively decreasing anteriorly: strong rib on shoulder and bearing nine very prominent tuberculate knobs; middle rib moderately strong and bearing more numerous nodes (about half sized of those on shoulder) that tend to become smaller and even obsolete adaxially; and most anterior periphery rib weakest and weak nodes tending to be obsolete adaxially. Base of last whorl usually with one or two spiral ribs, both bearing nodes (best developed near outer lip) or bearing no nodes, and with strength of spiral ribs decreasing anterior in direction; occasionally, anterior region of base with only very weak spiral riblets.



Figures 9–21. New cerithioid? gastropods. Specimens coated with ammonium chloride. **9–12.** *Bullamirifica verruca* new genus and species, LACMIP loc. 8133. **9.** Paratype LACMIP 13327, apertural view, height 27 mm, diameter 19.2 mm. **10–11.** Holotype LACMIP 13326, height 29.7 mm, diameter 17.8 mm. **10.** Apertural view. **11.** Abapertural view. **12.** Paratype LACMIP 13327, basal view, diameter 18.9 mm. **13–17.** *Bullamirifica elegans* new genus and species, LACMIP loc. 24337. **13–14.** Holotype LACMIP 13328, height 66.9 mm, diameter 34.9 mm. **13.** Apertural view. **14.** Abapertural view. **15–16.** Paratype LACMIP 13329, height 60.1mm, diameter 25.7 mm. **15.** Apertural view. **16.** Abapertural view. **17.** Holotype LACMIP 13328, basal view, diameter 35.7 mm. **18–21.** *Bullamirifica ainiktos* (Dailey and Popenoe, 1966) new genus. **18–19.** Hypotype LACMIP 13330, LACMIP loc. 10691, height 60 mm, diameter 24.1 mm. **18.** Apertural view. **19.** Abapertural view. **20.** Plasto-holotype LACMIP 40435, LACMIP loc. 24125, right-lateral view, height 58.2 mm, diameter 29.1 mm. **21.** Hyptotype LACMIP 13331, LACMIP loc. 24124, basal view, diameter 16.7 mm.

Aperture round with very small posterior "arch." Aperture elliptical, columellar lip smooth, outer lip thin; siphonal canal short and spout-like.

Holotype: LACMIP 13326, incomplete specimen with two whorls (upper spire missing), 29.7 mm height, 17.8 mm diameter.

Paratype: LACMIP 13327.

Type Locality: LACMIP loc. 8133.

Geologic Age: Coniacian.

Distribution: Redding Formation, Member IV, Oak Run area, northern California.

Etymology: Latin *verrucus*, wart.

Discussion: This new species is based on three specimens. It differs from *Bullamirifica elegans* new species below by smaller size and presence of rounded rather than elongate knobs, fewer knobs on shoulder of last whorl, no elongate collabral ridges on base of last whorl, a noded spiral rib coincident with the suture, and a straight siphonal canal. *Bullamirifica verruca* differs from *Bullamirifica ainiktos* by being smaller with a shorter spire and having rounded and much more projecting nodes, many fewer nodes on shoulder of last whorl, much less tendency for elongate collabral ridges on ramp, and much weaker spiral ribs between shoulder and anterior suture.

Bullamirifica verruca is very similar to the cerithioid *Tympanotonus* (*Tympanotonus*) *robustus* Dockery (1993: 47, pl. 7, fig. 1) in the shape of the spire, strong nodes on the spire, and shape of the growth lines next to the outer lip. *Tympanotonus* (*T.*) *robustus*, which is of Campanian age and from Mississippi, however, has no siphonal canal.

Bullamirifica elegans new species
(Figures 13–17)

[?] *Pseudoglauconia*? aff. *P. ainiktos* Dailey and Popenoe.—Elder and Saul, 1993: pl. 2, fig. 11.

Diagnosis: Large *Bullamirifica* with prominent opisthocline collabral ridges on upper spire and base of whorl. Shoulder of last whorl with 11 nodes. Suture coincident with unnoded weak spiral rib. Siphonal canal short but well developed and twisted to left.

Description: Medium large (up to 83 mm estimated height and 37 mm diameter, same specimen), fusiform, moderately wide, rarely slender. Height to diameter ratio approximately 2.2. Spire high, approximately 40% of shell height. Pleural angle approximately 33 to 42°, rarely approximately 30°. Protoconch and uppermost spire unknown. Teleoconch whorls approximately eight (estimated). Whorls with angulate shoulder. Ramp short and slightly concave. Collabral sculpture consisting of many moderately strong, narrow ribs; interspaces smooth. Collabral ribs extending from suture to suture. Collabral ribs sigmoidal between posterior suture and shoulder, opisthocline between shoulder and anterior suture. Collabral ribs somewhat swollen on base of last whorl. Spiral sculpture consisting of several ribs with variable strength and spacing. Intersections of collabral and spiral ribs producing many swollen, axially elongate nodes or, in some cases, rounded tuberculate knobs; nodes and knobs most prominent on shoulder. Spire whorls with strongest spiral rib on whorl shoulder and occasionally two moderately strong, noded spiral ribs between whorl shoulder and anterior suture. Suture coincident with weak spiral riblet. Penultimate whorl with spiral rib on shoulder bearing 11 widely spaced nodes. Last whorl with three or four spiral ribs on periphery, strongest rib on shoulder and bearing 11 nodes. Spiral ribs on periphery of last whorl usually show strength progressively decreasing anteriorly, occasionally rib immediately anterior of shoulder weaker than other ribs on periphery. Growth lines sigmoidal, with antispiral sinus coincident with shoulder. Aperture elliptical, columellar lip smooth, outer lip thin; siphonal canal short but well developed and slightly twisted to left.

Holotype: LACMIP 13328; nearly complete specimen of five whorls (upper spire missing), 66.9 mm height, 34.9 mm diameter.

Paratype: LACMIP 13329.

Type Locality: LACMIP loc. 24337.

Geologic Age: Early Campanian to possibly middle Campanian.

Distribution: Early Campanian: Chico Formation, Pentz Road member (informal), near Pentz, Butte County, northern California; Possibly middle Campanian: Pigeon Point Formation, San Mateo County, northern California.

Etymology: Latin *elegans*, meaning very fine or choice.

Discussion: The new species is based on six specimens from the Pentz area, and preservation is moderately good on all of them. Nearly all the specimens are moderately wide, but a few are somewhat slender, as the specimen illustrated in Figures 15–16.

There might be one specimen of the new species from the Pigeon Point Formation. This museum specimen, which cannot be located, was figured by Elder and Saul (1993: pl. 2, fig. 11). It was identified by them as *Pseudoglauconia*? sp. aff. *P. ainiktos* Dailey and Popenoe, but it has a profile somewhat more like *Bullamirifica elegans* and basal nodes like *B. elegans*. As will be discussed later, there are specimens of *B. ainiktos* from the Pigeon Point Formation. It seems likely that some of the *Bullamirifica* specimens from the Pigeon Point Formation represent transitional forms between *B. elegans* and *B. ainiktos*.

Bullamirifica elegans differs from *Bullamirifica verruca* in having larger size, prominent collabral ribs

extending from suture to suture on the spire whorls, swollen collabral ribs on the neck, more nodes on shoulder of the penultimate and last whorls, and siphonal canal longer and slightly twisted to the left. In addition, *B. elegans* occasionally has strong unnoded spiral ribs between suture and shoulder.

Bullamirifica elegans differs from *Bullamirifica ainiktos* by usually having a wider pleural angle, usually a less elevated spire, wider and stronger nodes on shoulder, fewer nodes on shoulder of last whorl, and base with swollen collabral ribs instead of fine spiral ribs. *Bullamirifica elegans* also has variability in morphology, whereas *B. ainiktos* does not.

Bullamirifica elegans is very similar to the cerithioid *Tympanotonus* (*Tympanotonus*) *binodosus* Dockery (1993: 47, pl. 7, fig. 2) in the shape of the spire, strong nodes on the spire, and shape of the growth lines next to the outer lip. *Tympanotonus* (*T.*) *binodosus* of Campanian age and from Mississippi, however, has no siphonal canal.

Bullamirifica ainiktos (Dailey and Popenoe, 1966) new combination
(Figures 18–25)

Pseudoglauconia? *ainiktos* Dailey and Popenoe, 1966: 21–22, pl. 6, figs. 3, 5, 6.
Pseudoglauconia? aff. *P. ainiktos* Dailey and Popenoe.—Elder and Saul, 1993: pl. 2, fig. 10.
Cimolithium miyakoense (Nagao, 1934). —Perrilliat-Montoya, 1968: 20, pl. 4, fig. 2.
Vicarya (*Shoshiroia*) *yabei* Kamada, 1960.—Perrilliat-Montoya, 1968: 21, pl. 6, fig. 1.

Diagnosis: Medium-size *Bullamirifica* with usually slender turreted whorls. Ramp on upper spire short, with narrow collabral ribs crossed by weaker spiral ribs; ramp on later whorls much longer and smooth and concave. Spire whorls concave on posterior half but angulate medially, with moderately strong tubercles. Shoulder of last whorl with 14 nodes. Base of last whorl with many, closely spaced spiral riblets. Siphonal canal short and possibly straight.

Description: Medium, up to 67.5 mm height estimated and 25.4 mm diameter, same specimen. Shell usually slender, turreted, occasionally wide, fusiform. Height to diameter ratio approximately 2.7. Spire high, approximately 55% of total shell height. Pleural angle approximately 33 to 37°. Protoconch unknown. Teleoconch whorls approximately eight (estimated). Spire whorls with shoulder angulate. Ramp usually short and concave, occasionally long and straight-sloped. Suture obscured. Collabral sculpture consisting of many spiral ribs closely spaced and narrow. Collabral ribs opisthocyrt, most prominent on ramp. Spiral sculpture consisting of several ribs, moderately weak and closely spaced. Intersections of collabral and spiral ribs producing many nodes, most prominent and somewhat spinose on shoulder. Spire whorls with strongest spiral rib on whorl shoulder and five moderately strong, non-noded spiral ribs between shoulder and anterior suture; most anterior one of these ribs coincident with suture. Penultimate and last whorls with approximately 14 nodes on shoulder. Last whorl with three spiral ribs on periphery, progressively weaker anteriorly, and bearing nodes. Base of last whorl bearing fine spiral riblets. Siphonal canal short and twisted to left. Columellar lip smooth. Outer lip sinuous; interior smooth.

Holotype: LACMIP 40435, incomplete specimen (tip of spire and siphonal canal missing), 39 mm height, 29 mm diameter.

Type Locality: LACMIP loc. 4125.

Geologic Age: Middle Campanian to Late Campanian.

Distribution: Middle Campanian: Pigeon Point Formation, near Pigeon Point, San Mateo County, northern California. Middle late Campanian: Punta Baja Formation, southwest of El Rosario, Baja California, Mexico. Late Campanian: Jalama Formation, Santa Barbara County, southern California.

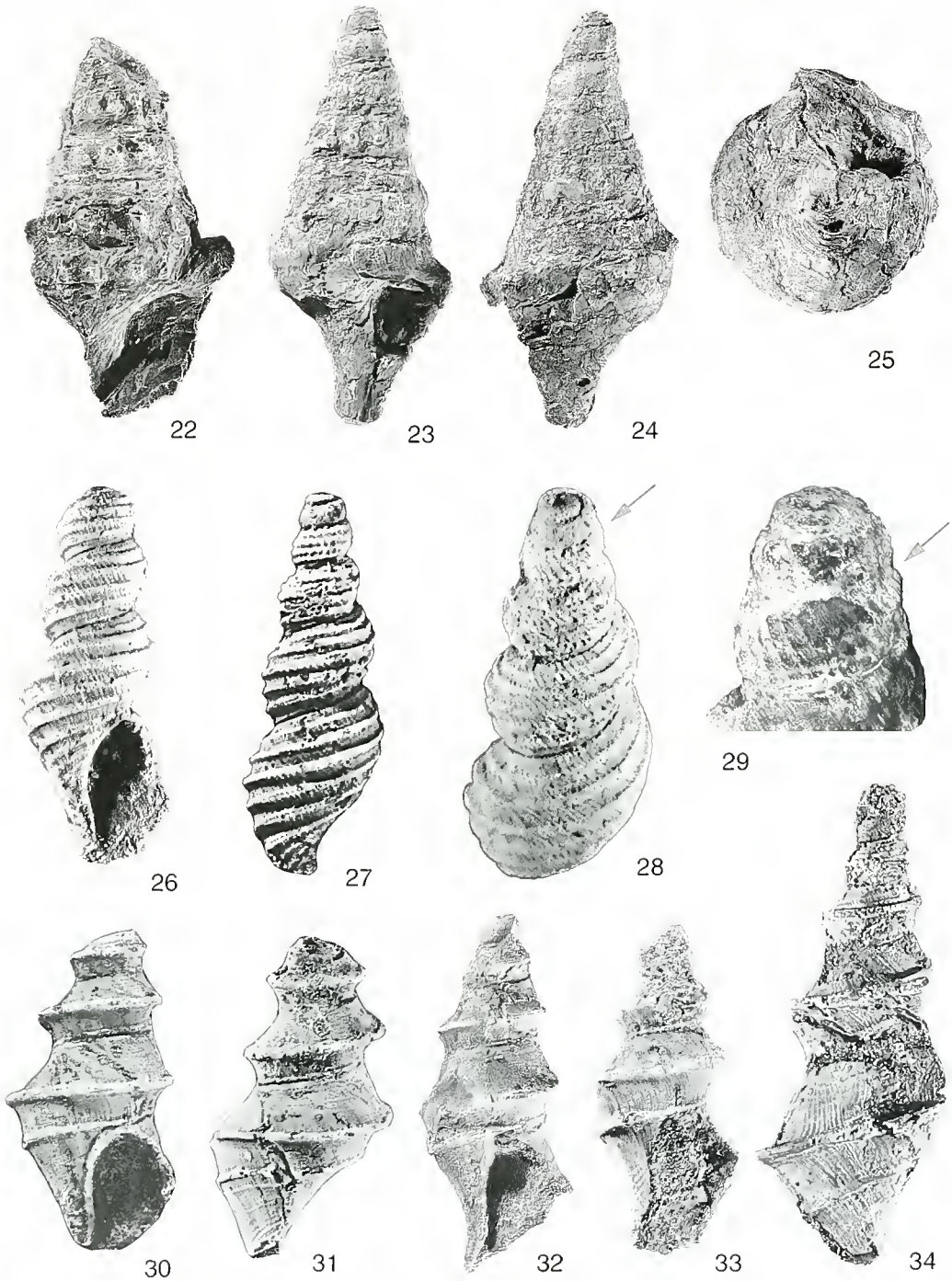
Discussion: Description of the new species is based on 25 specimens: 18 from the Jalama Formation, five from the Pigeon Point Formation, and two from the Punta Baja Formation. The Jalama specimens have poor to moderately good preservation, although the apices are broken off and the siphonal canal missing. The Pigeon Point specimens also have poor to moderately good preservation, but the matrix is very hard to remove. The Punta Baja specimens have poor preservation.

The Pigeon Point Formation specimen illustrated by Elder and Saul (1993: pl. 2, fig. 10) has a whorl profile like that found on *B. ainiktos* but it has wider pleural angle, similar to that found on *B. elegans*. Unfortunately this specimen is missing. As mentioned earlier, it seems likely that some of the *Bullamirifica* specimens from the Pigeon Point Formation represent transitional forms between *B. elegans* and *B. ainiktos*.

Bullamirifica ainiktos differs from *Bullamirifica verruca* by larger size and having less rounded and much lower nodes, more nodes on shoulder of last whorl, much more tendency for elongate collabral ridges on ramp, and much stronger spiral ribs between shoulder and anterior suture.

Bullamirifica ainiktos differs from *Bullamirifica elegans* by smaller size, having a narrower spire, usually a more elevated spire, narrower and weaker nodes on shoulder, more nodes on shoulder of last whorl, and base with fine ribs instead of swollen collabral ribs.

Perrilliat-Montoya (1968) identified one of the Punta Baja Formation specimens (Figures 23–25 herein) of *B. ainiktos* as *Vicarya* (*Shoshiroia*) *yabei* and identified the other specimen as *Cimolithium miyakoense*. With Wenz (1940: 740–741, fig. 2145) as a basis for comparison, we consider that *Bullamirifica ainiktos* differs considerably from the former gastropod by having a non-conical shell,



Figures 22–34. New cerithioid? and trichotropid gastropods. Specimens coated with ammonium chloride, unless otherwise noted. **22–25.** *Bullamirifica ainiktos* (Dailey and Popenoe, 1966) new genus. **22.** Hypotype LACMIP 13332, USGS loc. M-8601, height 35.8 mm, diameter 20 mm. **23–25.** Plasto-hypotype IGM 1325, height 80 mm, diameter 36.9 mm. **23.** Apertural view. **24.** Abapertural view. **25.** Basal view. **26–29.** *Minytropis melilota* new genus and species. **26.** Paratype LACMIP 13334, LACMIP loc. 10787, apertural view, height 7 mm, diameter 2 mm. **27–29.** Holotype LACMIP 13333, LACMIP loc. 10786, abapertural view, height 62 mm, diameter 2.2 mm. **27.** Abapertural view. **28.** Oblique apertural view of tip; arrow indicates where protoconch ends and teleoconch starts. **29.** Protoconch, height 0.5 mm, diameter 0.8 mm; arrow indicates where protoconch ends and teleoconch starts; SEM photomicrograph (uncoated). **30–34.** *Paxitropis dicriota* new genus and species. **30–31.** Paratype LACMIP 13336, LACMIP loc. 23643, height 12.7 mm, diameter 6.8 mm. **30.** Apertural view. **31.** Abapertural view. **32.** Holotype LACMIP 13335, LACMIP loc. 23639, apertural view, height 14.7 mm, diameter 6.6 mm. **33.** Paratype LACMIP 13337, LACMIP loc. 23642, apertural view, height 10.1 mm, diameter 4.4 mm. **34.** Paratype LACMIP 13338, LACMIP loc. 24217, abapertural view, height 11 mm, diameter 4.3 mm.

more rows of nodes, and absence of a notch on the outer lip near the suture and not having a thick, extensive callus that covers part of the noded sculpture near the suture on the last whorl. Using Kase (1984: 135–136, pl. 21, figs. 1–9; fig. 20) as a basis for comparison, we consider that *Bullamirifica ainiktos* differs considerably from the latter gastropod by having a much lower spire, more strongly sinuous growth lines, and a well developed, twisted siphonal canal.

Superfamily Capuloidea Fleming, 1822
Family Capulidae Fleming, 1822
?Subfamily Trichotropinae Gray, 1850

Discussion: We include a subfamily name because high-spired capulids, like those described below, are so distinctive from cap-shaped capulids. The subfamily allocation is tentative, pending much-needed taxonomic work on capulids.

Genus *Minytropis* new genus

Type Species: *Minytropis melilota* new species; Late Cretaceous, Santonian, northern California.

Description: Shell very small, estimated maximum height just over 10 mm. Shell thin, narrowly fusiform-elongate. Protoconch flat-topped and smooth, approximately two whorls. Teleoconch whorls rounded. Sculpture consisting of several strong spiral ribs with wide interspaces, both ribs and interspaces crossed by well delineated prosocline growth lines. Aperture oval, produced anteriorly to short, with narrow siphonal canal. Outer lip thin with no varix or inner denticulations. Inner lip callused, narrow.

Geologic Age: Early and Late Santonian.

Etymology: Combination of the Greek *minys*, meaning little, small, or short; and the Latin *tropis*, meaning keel.

Discussion: The placement of *Minytropis* among the trichotropids is suggested by the strongly prosocline and well marked growth lines, strong spiral sculpture, and the short, open siphonal canal. *Minytropis* resembles *Opposirius* Iredale, 1931, which is known only from the Recent of Australia (Wenz, 1940). *Minytropis* differs from *Opposirius* by having a narrower aperture, a longer siphonal canal, and a rounded rather than a bladelike inner lip.

Finlay and Marwick (1937) reported that *Opposirius* is more similar to *Cerithioderma* Conrad, 1860, than to any other trichotropid genus. In comparison to *Cerithioderma*, *Minytropis* is similar in having a flat-topped, smooth protoconch and in having a short siphonal canal, but *Minytropis* differs by having a much narrower shell, longer and much narrower aperture, stronger spiral sculpture, sculpture not recticulate on adult whorls, and no hint of an umbilicus. Wenz (1940) reported *Cerithioderma* to have a geologic range of Late Cretaceous to Oligocene, but Marwick (1965) reported that this genus is also extant. Dockery (1993) reported *Cerithioderma* from Campanian strata in Mississippi. High-spired trichotropids very similar to *Cerithioderma* are best represented in New Zealand Tertiary strata (Maxwell, 1992). According to Maxwell (1992), *Trichosirius* Finlay, 1926, might be a junior synonym of *Cerithioderma*.

Minytropis melilota new species
(Figures 26–29)

Description: Small, up to 10.2 mm estimated height and 3.5 mm diameter, same specimen. Shell narrowly fusiform-elongate. Spire high, 60% (estimated) of shell height. Pleural angle approximately 22 . Protoconch flat-topped, with two whorls, and smooth (0.5 mm height, 0.8 mm diameter). Teleoconch of approximately seven to eight subangulate whorls, last whorl nearly one-third total height. Suture deeply impressed, nearly coincident with very weak rib. Sculpture nearly cancellate on earliest teleoconch whorl, but four spiral riblets slightly stronger than numerous collabral threads. Sculpture on subsequent whorls progressing into five strong, flat-topped ribs on middle spire, six ribs on lower spire, and approximately eight to nine ribs on last whorl; most posterior spiral rib weak to very weak on all these whorls. Interspaces of nearly equal width on spire whorls but becoming twice as wide as ribs on last whorl. On last whorl, ribs on whorl face equally strong but on base, ribs become much less prominent and more closely spaced. Growth lines strongly prosocline, marked by fine collabral threads strongest on early whorls where they produce slight beading of spiral ribs. Growth lines less prominent and closer-spaced on later whorls; growth lines can be somewhat prominent on base of last whorl. Aperture oval, produced anteriorly to short, narrow siphonal canal. Outer lip thin, arcuate, crenulated by ribs. Columellar lip narrow, weakly callused, and barely forming a pseudo-umbilical chink between base of whorl and indistinct fasciole.

Dimensions of Holotype: Nearly complete specimen (siphonal canal mostly missing), 6.2 mm height, 2.2 mm diameter.

Holotype: LACMIP 13333.

Type Locality: LACMIP loc. 10786.

Paratype: LACMIP 13334.

Geologic Age: Early and Late Santonian.

Distribution: Lower Santonian: Redding Formation, Member V, Clover Creek, Shasta County, northern California. Upper Santonian: Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California.

Etymology: Latin *melilota*, meaning sweet clover (in reference to the occurrence of the new species near Clover Creek).

Discussion: Description of this new species is based on 29 specimens, most of which represented by small fragments. The better preserved specimens are all from the Redding Formation, however, none of these specimens is as large as the larger ones from the Chico Formation localities. Only two specimens, both from LACMIP loc. 10786, have retained the protoconch. The protoconch of one of these specimens is illustrated in Figures 27–29. The other specimen's protoconch is mostly embedded in hard matrix. The flat-topped protoconch of *M. meliota* supports the position of this gastropod among the Trichotropidae.

The new species can be distinguished from the similar looking *Opposirius idoneus* Iredale (1931: 210, pl. 22, fig. 7; Wenz, 1940: fig. 2631), an extant species in southwestern Australia, by having a narrower shell, one more rib on the spire, two to four more ribs on the base of the last whorl, a much longer siphonal canal, an a rounded columella. *Opposirius idoneus* is the type species of *Opposirius* Iredale, 1931.

Genus *Paxitropis* new genus

Type Species: *Paxitropis dicriota*; Late Cretaceous, late Santonian to early Campanian, northern California.

Description: Shell medium small, narrowly pagodiform. Spire whorls with prominent keel medially. Suture bordered posteriorly by relatively weak spiral rib becoming keel-like on last whorl and, in concert with aforementioned keel, producing bicarinate last whorl. Shell base with several weak spiral riblets. Growth lines prosocline. Columellar lip callused, abaxial margin well-delineated. Siphonal canal short but distinct. Anomphalous.

Geologic Age: Late Santonian to early Campanian.

Etymology: Combination of the Latin *pax*, meaning peace (in reference to the peaceful Pacific coast); and the Latin *tropis*, meaning keel.

Discussion: *Paxitropis* is similar to *Trichotropis* Broderip and Sowerby, 1829, a genus known (Sohl, 1960) from the Late Cretaceous to Recent. The modern distribution of *Trichotropis* is restricted to circum-boreal waters, in both the northern and southern oceans and, as Sohl (1960) noted, this modern distribution is in sharp contrast to its Cretaceous distribution in temperate shallow-water deposits. *Paxitropis* differs from *Trichotropis* by having a smaller size, much narrower shell (including a narrower aperture), a siphonal canal, much lower variability in sculpture, and being anomphalous.

Paxitropis resembles the trichotropid *Iciuncula* Iredale, 1924, which is known from the Recent of the Indo-Pacific (Wenz, 1940). *Paxitropis* differs from *Iciuncula* by having no hint of an umbilicus, less prominent keels that are unwavy, one less keel on the last whorl, and no axial riblets on the ramp. The aperture of *Paxitropis* is not entirely known.

The new genus has a whorl profile very similar to the turrid *Austrocarina* Laseron, 1954, known only from the Recent of New South Wales and Victoria, southeastern Australia and Tasmania. *Paxitropis*, however, is not a turrid because it does not have the turrid growth lines, which tend to be opisthocline anterior to the notch and across the whorl periphery curving toward prosocline very near the siphonal area.

Paxitropis dicriota new species
(Figures 30–34)

Description: Shell small, up to height estimated 14.5 mm and 6.6 mm diameter. Shell pagodiform. Spire high, approximately 60% of shell height. Pleural angle approximately 30°. Protoconch unknown. Teleoconch approximately six strongly angulated whorls, with wide ramp on middle spire whorls and on last whorl. Sculpture dominated by prominent spiral rib, medially located on shoulder and keel-forming on later whorls. Early teleoconch whorls with two spiral ribs anterior to carina. On mature whorls, these additional ribs become mere threads and equivalent in strength to growth lines, thus producing microscopic cancellate surface, especially on ramp. Suture impressed, nearly coincident with weakly noded subsutural spiral rib located immediately posterior to suture. Subsutural spiral rib relatively weak on spire whorls but becoming keel-like on last whorl. Last whorl with two sharp keels, one just above middle whorl height and second one weaker and occasionally minutely noded, emergent at anterior suture. Shell base with several weak spiral ribs. Growth lines prosocline, most prominent on shell base, near outer lip. Aperture lanceolate and produced anteriorly to short, but distinct siphonal canal. Outer lip thin, angulate, crenulated by ribs. Columellar lip callused, abaxial margin well-delineated. Columellar lip narrow, barely forming pseudo-umbilical chink between base of whorl and indistinct fasciole.

Holotype: LACMIP 13335, 14.7 mm height, 6.6 mm diameter.

Paratypes: LACMIP 13336, 13337, and 13338.

Type Locality: LACMIP loc. 23643.

Geologic Age: Late Santonian to Early Campanian.

Distribution: Upper Santonian: Redding Formation, Member VI, area east of Redding, Shasta County, northern California. Lower Campanian: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California; Ladd Formation, upper Holz Shale Member, Santa Ana Mountains, Orange County, southern California.

Etymology: Combination of the Greek *di*, meaning two, and the Greek *criota*, meaning ringed.

Discussion: Twenty incomplete specimens were available, and the six most complete of these are the basis for the above description. The only specimen from the

Redding Formation is geologically the oldest specimen (LACMIP loc. 24217). The only specimen from the upper Holz Shale is from LACMIP loc. 21536.

The new species is very similar to the Pliocene to Recent *Trichotropis bicarinata* (Sowerby, 1825; Pitt and Pitt, 1989: pl. 1, figs. 3–4; Egorov and Alexeyev, 1998: 25, figs. 22–23), which is a Pacific upper boreal Arctic species, occurring in the waters off northern Japan, Kamchatka, southern Chukchi Sea, and Queen Charlotte Islands in British Columbia (Egorov and Alexeyev, 1998). The new species differs from *T. bicarinata* by having a much narrower last whorl and a much narrower aperture. These same differences distinguish the new species from *Trichotropis vokesae* Pitt and Pitt, 1989, which is extremely similar to *T. bicarinata*. *Trichotropis vokesae* is of Pliocene age and from northwestern Ecuador, and the new species differs from *T. vokesae* in the same ways that it differs from *T. bicarinata*.

The new species can be distinguished from the similar looking *Icuncula torcularis* (Tenison-Woods 1879; Wenz, 1940: fig. 2630), an extant species living off the coasts of southeastern Australia and Tasmania, by having less projecting and non-wavy keels, one less keel on the last whorl, and an absence of axial riblets on the ramp. *Icuncula torcularis* is the type species of *Icuncula* Iredale, 1924.

The new species is remarkably similar to the extant *Austrocarina recta* (Hedley, 1903; 1922: 223, fig. 3; Powell, 1966: 34, pl. 3, fig. 2; 1969: 364, pl. 276; Wilson, 1994: 187) but differs from *A. recta* by having a shell approximately 14 mm in height instead of 6 mm, a more projecting and usually wider keel on the shoulder of the adult whorls, several weak spiral ribs on base of last whorl, several spiral ribs on earliest teleoconch whorls, straight rather than a curved profile of the base, columellar lip callused with abaxial margin well-delineated, and no tendency to develop collabral ribs on earliest teleoconch whorls.

ACKNOWLEDGMENTS

The authors are especially grateful for the careful and tireless collecting of Eric Göhre of Oroville, California. Without his help and willingness to donate the material, the paper would have been greatly reduced in its scope. James H. McLean, Natural History Museum of Los Angeles County, Malacology Division, provided valuable comments about the identification of the new trochid. Carmen Perrilliat (IGM) graciously sent us excellent casts of the Punta Baja Formation material. David Haasl (UCMP) spent considerable effort unsuccessfully trying to locate the hypotypes of *Bullamirifica ainiktos* from the Pigeon Point Formation. Jorge Vazquez, California State University, Northridge, kindly took SEM photomicrographs of the protoconch of *Minytropis melilota*. Steffen Kiel (Smithsonian Institution) and an anonymous reviewer critiqued the manuscript.

LITERATURE CITED

Adams, A. 1855. Further contributions toward the natural history of the Trochidae: with the description of a new genus and of several new species, from the Cumingian collection. Proceedings of the Zoological Society of London for 1854: 33–41.

Addicott, W. O. 1973. Oligocene molluscan biostratigraphy and paleontology of the lower part of the type Temblor Formation, California. U. S. Geological Survey Professional Paper 791: 1–48.

Albers, H. J. 1976. Feinstratigraphie, Faziesanalyse und Zyklen des Untercampans (Vaalser Grünsands = Hervien) von Aachen und dem niederländisch-belgischen Limburg. Geologisches Jahrbuch, A, 34, 3–68.

Almgren, A. A. 1986. Benthic foraminiferal zonation and correlations of Upper Cretaceous strata of the Great Valley of California—a modification. In P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, Society of Economic Paleontologists and Mineralogists 46: 137–152.

Anderson, F. M. and G. D. Hanna. 1935. Cretaceous geology of Lower California. Proceedings of the California Academy of Sciences, Series 4, 23(1): 1–34.

Arnold, R. 1908. Descriptions of new Cretaceous and Tertiary fossils from the Santa Cruz Mountains, California. Proceedings of the United States National Museum 34: 345–390.

Bandel, L. K. and S. Kiel. 2003. Relationships of Cretaceous Neritimorpha (Gastropoda, Mollusca), with the description of seven new species. Bulletin of the Czech Geological Survey 78: 49–62.

Bandel, K. and W. Stinnesbeck. 2000. Gastropods of the Quiriquina Formation (Maastrichtian) in central Chile: paleobiogeographic relationships and the description of a few new taxa. Zentralblatt für Geologie und Paläontologie Teil 1(Heft 7/8): 757–788.

Benson, W. H. 1842. Mollusca. *In:* T. Cantor (ed.) General Features of Chusan, with Remarks on the Flora and Fauna of that Island. Annals and Magazine of Natural History, Series 1, 9: 486–490.

Boehlke, J. E. and P. L. Abbott. 1986. Punta Banda Formation, a Campanian submarine canyon fill, Baja California, Mexico. *In:* P. L. Abbott (ed.) Cretaceous Stratigraphy Western North America. Pacific Section, Society of Economic Paleontologists and Mineralogists 46: 91–101.

Broderip, W. J. and G. B. Sowerby, I. 1829. Observations on new or interesting Mollusca contained, for the most part, in the Museum of the Zoological Society. Zoological Journal 4(15): 359–376.

Clark, B. L. 1938. Fauna from the Markley Formation (upper Eocene) on Pleasant Creek, California. Bulletin of the Geological Society of America 49: 683–730.

Conrad, T. A. 1860. Descriptions of new species of Cretaceous and Eocene fossils of Mississippi. Journal of the Academy of Natural Sciences of Philadelphia, Series 2, 4(3): 275–298.

Dailey, D. H. and W. P. Popenoe. 1966. Mollusca from the Upper Cretaceous Jalama Formation, Santa Barbara County, California. University of California Publications in Geological Sciences 65: 1–27.

Davies, A. M. 1971. Tertiary Faunas, a text-book for oilfield palaeontologists and students of geology. Volume 1. The Composition of Tertiary Faunas, revised by F. E. Eames. George Allen and Unwin, London, 571 pp.

Dockery, D. THH. 1993. The streptoneuran gastropods exclusive of the Stenoglossa, of the Coffee Sand (Campanian) of northeastern Mississippi. Mississippi Department of Environmental Quality, Office of Geology, Bulletin 129: 1–191.

Douvillé, H 1921. Mélanges paleóntologiques: genre *Eovasum*. Glauconiidae, Pleuroceratidae, Pirenidae, genre *Itruvia*. Journal de Conchyliologie 66: 1–18.

Egorov, R. and D. Alexeyev. 1998. Treasure of Russian Shells. Volume 2, Trichotropidae Moscow, 36 pp.

Elder, W. P. and L. R. Saul. 1993. Paleogeographic implications of molluscan assemblages in the Upper Cretaceous (Campanian) Pigeon Point Formation, California. *In:* G. Dunne and K. McDougall (eds.) Mesozoic Paleogeography of the Western United States-II. Pacific Section, Society of Economic Paleontologists and Mineralogists 71: pp. 171–186.

Elder, W. P. and L. R. Saul. 1996. Taxonomy and biostratigraphy of Coniacian through Maastrichtian *Anchura* (Gastropoda: Aporrhaidae) of the North American Pacific slope. Journal of Paleontology 70: 381–397.

Férussac, D. 1819. Histoire naturelle générale e pariticulière des mollusques terrestres et fluviatiles. Volume 1, Paris, 128 pp.

Finlay, H. J. 1926. A further commentary on New Zealand molluscan systematics. Transactions of the New Zealand Institute 57: 320–485.

Finlay, H. J. and J. Marwick. 1937. The Wangaloan and associated molluscan faunas of Kaitangata-Green Island subdivision. New Zealand Department of Scientific and Industrial Research, Geological Survey Branch, Palaeontological Bulletin 15: 1–140.

Fleming, J. 1822. Philosophy of Zoology. Volume 2. Edinburgh, 618 pp.

Gabb, W. M. 1864. Description of the Cretaceous fossils. Geological Survey of California, Palaeontology 1: 57–243.

Goudkoff, P. P. 1945. Stratigraphic relations of Upper Cretaceous in the Great Valley, California. American Association of Petroleum Geologists Bulletin 29: 956–1007.

Gradstein, F. M., J. G. Ogg and A. G. Smith. 2004. A geologic time scale 2004. Cambridge University Press, Cambridge, 589 pp.

Grant, U. S., IV and H. R. Gale. 1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions. Memoirs of the San Diego Society of Natural History 1: 1–1036.

Gray, M. E. 1850. Figures of molluscous animals, selected from various authors. Volume 2, London, pls. 79–199.

Groves, L. T. 2004. New species of Late Cretaceous Cypraeidae (Gastropoda) from California and British Columbia and new records from the Pacific slope. The Nautilus 118: 43–51.

Hedley, C. 1903. Scientific results of the trawling expedition of H.M.C.S. "Thetis" off the coast of New South Wales in February and March, 1896. Mollusca. Part II. Scaphopoda and Gastropoda. Memoirs of the Australian Museum 4: 327–402.

Hedley, C. 1922. A revision of the Australian Turridae. Records of the Australian Museum 13(6): 213–259.

Hickman, C. S. and J. H. McLean. 1990. Systematic revision and suprageneric classification of trochacean gastropods. Natural History Museum of Los Angeles County, Science Series 35: 1–169.

Holzapfel, E. 1888. Die Mollusken der Aachener Kreide. Paleontographica 34: 29–180.

Houbrick, R. S. 1988. Cerithioidean phylogeny. *In:* W. F. Ponder, D. J. Eernisse and J. H. Waterhouse (eds), Prosobranch Phylogeny. Malacological Review, Supplement 4: 88–128.

Iredale, T. 1924. Results from Roy Bell's molluscan collections. Proceedings of the Linnaean Society of New South Wales 49: 179–278.

Iredale, T. 1931. Australian molluscan notes. I. Records of the Australian Museum 18: 201–235.

Kanada, Y. 1960. On the associated occurrence of *Vicarya* and *Vicaryella* in the Japanese Tertiary, with the first description of a Paleogene species of *Vicarya* from Japan. Science Reports of Tohoku University, Series 2, Special Volume 4: 281–295.

Kase, T. 1984. Early Cretaceous marine and brackish-water Gastropoda from Japan. National Science Museum, Tokyo. 263 pp.

Keen, A. M. 1960. Superfamily Trochacea Rafinesque, 1815. *In:* R. C. Moore (ed.) Treatise on Invertebrate Paleontology. Pt. I. Mollusca 1. Geological Society of America and University of Kansas Press, Lawrence, pp. 1246–1275.

Kiel, S. and K. Bandel. 2001. Trochidae (Archaeogastropoda) from the Campanian of Torallola in northern Spain. Acta Geologica Polonica 51(2): 137–154.

Kilmer, F. H. 1963. Cretaceous and Cenozoic stratigraphy and paleontology, El Rosario area. University of California, Berkeley, unpublished Ph. D. dissertation, 149 pp.

Kuroda, A. T., T. Habe and K. Oyama. 1971. The Sea Shells of Sagami Bay. Maruzen Co., Ltd., Tokyo, 1281 pp.

Lamarck, J. B. 1804. Mémoires sur les fossiles des environs de Paris. Annales de Muséum National d'Histoire Paris. Tome 5, variously paged. Reprinted 1978, Paleontological Research Institution, Ithaca, New York.

Laseron, C. F. 1954. Revision of the New South Wales TurridaeAustralian Zoological Handbook. Royal Zoological Society of New South Wales, Sydney, 56 pp.

Lesson, R. P. 1835. Illustrations de zoologie ou recueil de figures d'animaux peintes d'apres. Paris, 17 pls.

Linnaeus, C. 1758. Systema naturae per regna tria naturae. Regnum animale. Editio decima reformata. Volume 1. Laurentii Salvii, Stockholm, 824 pp.

McLean, J. H. 1978. Marine shells of southern California, revised edition. Natural History Museum of Los Angeles County, Science Series 24: 1–104.

Marwick, J. 1965. Upper Cenozoic Mollusca of Wairoa district, Hawke's Bay. New Zealand Geological Survey Paleontological Bulletin 39: 1–83.

Maxwell, P. A. 1992. Eocene Mollusca from the vicinity of McCulloch's Bridge, Waiho River, South Canterbury, New Zealand: paleoecology and systematics. New Zealand Geological Survey Paleontological Bulletin 65: 1–280.

Montfort, P. D. 1810. Conchyliologie systématique et classification méthodique des coquilles. Volume 2. F. Schoell, Paris, 176 pp.

Nagao, T. 1934. Cretaceous Mollusca from the Miyako District, Honshû, Japan. Journal of the Faculty of Science. The Hokkaido Imperial University, Series 4, 2: 177–277.

Perrilliat-Montoya, M. C. 1968. Fauna del Cretácio y del Terciario del norte de Baja California. Universidad Nacional Autónoma de México, Instituto de Geologa, Paleontologa Mexicana 25: 1–26.

Philippi, R. A. 1887. Die Tertiären und Quartären versteinerungen Chiles. F. A. Brockhaus, Leipzig, 266 pp.

Pitt, W. D. and L. J. Pitt. 1989. A new species of *Trichotropis* (Gastropoda: Mesogastropoda) from the Esmeralda beds, Onzole Formation, northwestern Ecuador. Tulane Studies in Geology and Paleontology 22: 131–136.

Ponder, W. F. 1998. Superfamily Capuloidea. *In*: P. L. Beesley, G. J. B. Ross and A. Wells (eds.), Mollusca: the Southern Synthesis. Fauna of Australia. Volume 5. CSIRO Publishing, Melbourne, Part B, pp. 774–775.

Ponder, W. F. and A. Warén. 1988. Appendix. Classification of the Caenogastropoda and Heterostropha—a list of the family-group names and higher taxa. *In*: W. F. Ponder, D. J. Eernisse and J. H. Waterhouse (eds.) Prosobranch Phylogeny. Malacological Review, Supplement 4: 288–326.

Powell, A. W. B. 1966. The molluscan families Speightiidae and Turridae: An evaluation of the valid taxa, both Recent and fossil, with lists of characteristic species. Bulletin of the Auckland Institute and Museum 5: 1–184.

Powell, A. W. B. 1969. The family Turridae in the Indo-Pacific. Part 2. The subfamily Turriculinae. Indo-Pacific Mollusca 2(10): 207–416.

Quintero, I. and J. Revilla. 1966. Algunas especies nuevas y otra poco conocidas. Notas y Communicaciones del Instituto Geologico y Minero de España 82: 27–86.

Rafinesque, C. S. 1815. Analyse de la Nature on Tableau de Univers et des Corps Organisées. Barraceccchia, Palermo, 224 pp.

Saul, L. R. 1983. *Turritella* zonation across the Cretaceous-Tertiary boundary, California. University of California Publications Geological Sciences 125: 1–165.

Saul, L. R. and W. P. Popenoe. 1992. Pacific slope Cretaceous bivalves of the genus *Calva*. Natural History Museum of Los Angeles County, Contributions in Science 433: 1–68.

Saul, L. R. and R. L. Squires. 1997. New species of neritid gastropods from Cretaceous and Lower Cenozoic strata of the Pacific slope of North America. The Veliger 40: 131–147.

Saul, L. R. and R. L. Squires. 2003. New Cretaceous cerithiform gastropods from the Pacific slope of North America. Journal of Paleontology 77: 442–453.

Smith, J. P. 1900. The development and phylogeny of *Placenticeras*. Proceedings of the California Academy of Sciences, Series 3, 1(7): 180–240.

Sohl, N. F. 1960. Archeogastropoda, Mesogastropoda and stratigraphy of the Ripley, Owl Creek, and Prairie Bluff formations. U. S. Geological Survey Professional Paper 331-A: 1–151.

Sowerby, G. B., I. 1825. A catalogue of the shells contained in the collection of the late Earl of Tankerville. London, 92 pp.

Squires, R. L. 2003. Turnovers in marine gastropod faunas during the Eocene-Oligocene transition, west coast of the United States. *In*: D. R. Prothero, L. C. Ivany and E. A. Nesbitt (eds.) From Greenhouse to Icehouse: the Marine Eocene-Oligocene Transition. New York: Columbia University Press, pp. 14–35.

Squires, R. L. and L. R. Saul. 1997. Late Cretaceous occurrences on the Pacific slope of North America of the melanopsid gastropod genus *Boggsia* Olssen, 1929. The Veliger 40: 193–202.

Squires, R. L. and L. R. Saul. 2001. New Late Cretaceous gastropods from the Pacific slope of North America. Journal of Paleontology 75: 46–65.

Squires, R. L. and L. R. Saul. 2002. New information on Late Cretaceous, Paleocene, and Eocene neritid gastropods from the North American Pacific slope. The Veliger 45: 177–192.

Squires, R. L. and L. R. Saul. 2003a. Additions to Late Cretaceous shallow-marine gastropods from California. The Veliger 46: 145–161.

Squires, R. L. and L. R. Saul. 2003b. New Late Cretaceous (Campanian and Maastrichtian) marine gastropods from California. Journal of Paleontology 77: 50–63.

Squires, R. L. and L. R. Saul. 2004. The pseudomelaniid gastropod *Paosia* from the marine Cretaceous of the Pacific slope of North America and a review of the age and paleobiogeography of the genus. Journal of Paleontology 78: 484–500.

Tenison-Woods, J. E. 1879. On some new species of Tasmanian marine shells. Proceedings of the Royal Society of Tasmania for 1878: 32–40.

Thiele, J. 1929–1935. Handbuch der systematischen Weichtierkunde. Gustav Fischer, Jena, pp. 1–1154.

Vedder, J. G. 1977. Preliminary list of Late Cretaceous mollusks from the Pozo district, San Luis Obispo County, California. *In*: D. G. Howell, J. G. Vedder and K. McDougall (eds.), Cretaceous Geology of the California Coast Ranges, West of the San Andreas Fault. Pacific Section Society of Economic Paleontologists and Mineralogists, Pacific Coast Paleogeography Field Guide 2: pp. 107–109.

Wenz, W. 1938–1944. Gastropoda. Teil 1: Allgemeiner Teil und Prosobranchia. *In*: O. H. Schindewolf (ed.), Handbuch der Paläozoologie, Band 6. Gebrüder Borntraeger, Berlin, pp. 1–1639. [Reprinted 1960–1961].

Wilson, B. 1994. Australian marine shells. Prosobranch gastropods, Part 2 (Neogastropoda). Odyssey Publishing, Kallaroo, Western Australia, 370 pp.

Woods, A. J. C. and L. R. Saul. 1986. New Neritidae from southwestern North America. Journal of Paleontology 60: 636–655.

Woods, H. 1906. The Cretaceous fauna of Pondoland. Annals of the South African Museum 4: 275–350.

APPENDIX 1

LOCALITIES CITED

Localities are LACMIP, unless otherwise noted. All quadrangle maps listed below are U. S. Geological Survey maps.

10786. Near crest of south slope of divide between Basin Hollow and Clover creeks, at approximately southeast corner of the northwest 1/4 of section 33, T. 32 N, R. 2 W. Lower Santonian. Redding Formation, Member V (lower part). Coll.: W. P. Popenoe and D. W. Scharf, August 8, 1931.

10787. Near crest of north slope of divide between Basin Hollow and Clover creeks, near northeast corner of northwest 1/4 of section 33 and not more than 122 m south of section line, T. 32 N, R. 2 W. Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Lower Santonian. Redding Formation, Mem-

ber V (lower part). Coll.: W. P. Popenoe and D. W. Scharf, August 8, 1931.

12582. Turritellas and oysters along beach just south of La Bocana Roja Formation outcrop, approximately 2 km north of south tip on west side of Punta Baja, Mexico. Middle upper Campanian. Punta Baja Formation. Coll.: L. R. Saul, October 12, 1990.

21536. Corona Quadrangle, Santa Ana Mountains, Orange County, southern California. Lower Campanian. Ladd Formation, upper Holz Shale Member. Coll.: T. Bear, 1940.

23639. East bank of Chico Creek in concretions in massive, greenish-gray sandstone, 373 m south and 293 m west of northeast corner of section 23, T. 23 N, R. 2 E, Paradise Quadrangle (15 minute, 1953), Butte County, northern California. Lower Campanian. Chico Formation, Ten Mile Member. Coll.: L. R. and R. B. Saul, August 20, 1952.

23642. On W bank of Chico Creek, west of big westward projection of east lava cap and approximately N 27°W of BM 1770, 122 m south and 632 m west of northeast corner of section 26, T. 23 N, R. 2 E, Paradise Quadrangle (15 minute, 1953), Butte County, northern California. Lower Campanian. Chico Formation, Ten Mile Member. Coll.: L. R. and R. B. Saul, August 20, 1952.

23643. Concretionary sandstone on west side of Big Chico Creek, 670 m south and 762 m west of northeast corner of section 26, T. 23 N, R. 2 E, Paradise Quadrangle (7.5 minute, 1953), Butte County, northern California. Lower Campanian. Chico Formation, Ten Mile Member. Coll.: L. R. Saul and R. B. Saul, August, 1952.

24124. Hard, medium-grained, gray, arkosic sandstone, 158 m north of Jalama Creek, 3.3 km west and 0.6 km north of southeast corner of the topographic sheet, Lompoc Hills Quadrangle (7.5 minute, 1947). Upper Campanian. Jalama Formation. Coll.: D. Dailey and J. R. Dorrance, October, 1929.

24125. Hard, fine to medium-grained arkosic sandstone, 2.8 km west and 0.53 km north of southeast corner of the topographic sheet, Lompoc Hills Quadrangle (7.5 minute, 1947). Upper Campanian. Jalama Formation. Coll.: D. Dailey and J. R. Dorrance, October 29, 1929.

24217. Hard sandstone slabs in bed of Clover Creek, 213 m north and 366 m west of southeast corner of section 22, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Upper Santonian. Redding Formation, Member VI. Coll.: W. P. Popenoe and D. Dailey, August 27, 1959.

24337. Along east side of Highway 70, 792 m north and 305 m west of southeast corner of section 36, T. 21 N, R. 3 E, Cherokee Quadrangle (7.5 mintue, 1949), Butte County, northern California. Lower Campanian. Chico Formation, Pentz Road member (informal). Coll.: E. Göhre.

UCMP B-3388. In south-trending arroyo which reaches coast about 2.8 km north of the tip of Punta Baja. Marine invertebrates from massive, chert conglomerate at confluence of this arroyo and northwest-trending tributary about 122 m upstream from confluence. This locality is abont 488 m northwest of the Punta Baja road. Middle upper Campanian. Punta Baja Formation. Coll.: F. H. Kilmer, date unknown.

USGS M-8601. In lens in sandstone on beach 0.5 km southeast of Bolsa Point, Pigeon Point Quadrangle, San Mateo County, northern California. Middle Campanian. Pigeon Point Formation. Coll.: W. P. Elder, 1989?